

## PLASMA CHAMBER

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 2003-38023, filed June 12, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

## BACKGROUND OF THE INVENTION

## Field of the Invention

The present invention relates to a plasma chamber, and more particularly, to a capacitively coupled plasma (CCP) chamber for dry etching.

## Description of the Related Art

In a process of manufacturing a liquid crystal display (LCD), a capacitively coupled plasma (CCP) method, an inductively coupled plasma (ICP) method, etc. are being used to form plasma. Particularly, the ICP method that uses an inductive electromagnetic field by generating plasma is widely used because it is possible to form high-density plasma and it is easy to control ion energy by using bias power. On the other hand, the CCP method forms low-density plasma as compared with the ICP method, but is also widely used for etching because it has advantages of a simple equipment, etc.

FIG. 1 schematically shows a conventional dry etching

apparatus using the capacitively coupled plasma.

As shown in FIG. 1, a dry etching apparatus 100 comprises a CCP plasma chamber 110, and a main power supply 120.

The CCP plasma chamber 110 comprises a receptor 111, a lower electrode 112 and an upper electrode 113.

The receptor 111 is placed in an inside lower part of the CCP plasma chamber 110 and supports a panel to which photosensitive material is applied for etching. The lower electrode 112 contacts a bottom of the receptor 111 and supplies power to the receptor 111. The upper electrode 113 is placed in an inside upper part of the CCP plasma chamber 110 and is grounded as a reference electrode with respect to the lower electrode 112.

The main power supply 120 comprises a main power source 121 and an impedance matching circuit 122.

The main power source 121 supplies alternating current (AC) power having predetermined frequency and predetermined amplitude, and is connected to the lower electrode 112. The impedance matching circuit 122 is electrically connected between the lower electrode 112 and the main power source 121, and prevents the AC power supplied from the main power source 121 from being reversed at the lower electrode 112.

With this configuration, the conventional dry etching apparatus 100 is operated as follows.

First, a reaction panel is put on the receptor 111. Then, nearly all gases are evacuated from the CCP plasma chamber 110 by a vacuum pump (not shown) through an exhaust hole (not shown), thereby vacuumizing the CCP plasma chamber 110. Then, a reaction gas is fed into the CCP plasma chamber 110 through an introduce hole (not shown).

After completing preparation for an etching process, the AC power is supplied and the etching process is started.

When the AC power is supplied to the lower electrode 112 from the main power source 121, a time-varying electric field is generated between the lower electrode 112 and the upper electrode 113. Such time-varying electric field resolves the reaction gas into an ion, a negative electric charge and a radical. Here, the ion physically collides with and chemically reacts to a thin film of the reaction panel by electric force, and the radical physically collides with and chemically reacts to the thin film of the reaction panel by diffusion, thereby etching the reaction panel. Particularly, in the case of responsive ion etching (IRE), anisotropic etching is performed according to the electric field because the ion is accelerated by the electric field and collides with the thin film.

However, in the conventional dray etching apparatus 100, a bias electric field for the etching varies according to the amplitude and the frequency of the main power source

121. Thus, there is a limit to precisely control etching conditions such as an etching rate, an etching profile, a selection ratio, etc.

#### SUMMARY OF THE INVENTION

Accordingly, it is an aspect of the present invention to provide a plasma chamber in which etching conditions such as an etching rate, an etching profile, a selection ratio, etc. are precisely adjusted.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

The foregoing and/or other aspects of the present invention are achieved by providing a plasma chamber comprising a lower electrode and an upper electrode, and used for dry-etching an LCD, comprising: a main power supply comprising a main power source to generate a main voltage having a predetermined main frequency, and a first impedance matching circuit to impedance-match the main voltage; a bias power supply comprising a bias power source to generate a bias voltage having a predetermined bias frequency, and a second impedance matching circuit to impedance-match the bias voltage; and a mixer connected to both the first impedance matching circuit and the second impedance matching circuit, receiving and mixing the main

voltage and the bias voltage, and outputting the mixed voltage to one of the lower electrode and the upper electrode.

According to an aspect of the invention, the plasma chamber further comprises at least one auxiliary power supply comprising an auxiliary power source to generate an auxiliary voltage having a predetermined frequency, and an auxiliary impedance matching circuit to impedance-match the auxiliary voltage, wherein the mixer is connected to the auxiliary impedance matching circuit of the auxiliary power supply, receives and mixes the main voltage, the bias voltage and the auxiliary voltage, and outputs the mixed voltage to one of the lower electrode and the upper electrode.

According to an aspect of the invention, the mixer outputs the mixed voltage by adding the received voltages.

According to an aspect of the invention, the bias frequency is lower than the main frequency.

#### BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the present invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompany drawings of which:

FIG. 1 is a schematic view of a conventional dry etching apparatus using capacitively coupled plasma; and

FIG. 2 is a schematic view of a dry etching apparatus using capacitively coupled plasma according to an embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

FIG. 2 schematically shows a dry etching apparatus using capacitively coupled plasma according to an embodiment of the present invention.

As shown in FIG. 2, a dry etching apparatus 1 comprises a CCP plasma chamber 10, and a power supply 20.

The CCP plasma chamber 10 comprises a receptor 11, a lower electrode 12 and an upper electrode 13. The receptor 11 is placed in an inside lower part of the CCP plasma chamber 10 and supports a reaction panel to which photosensitive material is applied for etching. The lower electrode 12 contacts a bottom of the receptor 11. The upper electrode 13 is placed in an inside upper part of the CCP plasma chamber 10 and is grounded as a reference electrode with respect to the lower electrode 12.

The power supply 20 comprises a main power supply 30,

a bias power supply 40, and a mixer 50.

The main power supply 30 comprises a main power source 31, and a first impedance matching circuit 32. The main power source 31 supplies alternating current (AC) power having a predetermined angular frequency ( $\omega_1$ ) and a predetermined amplitude ( $E_1$ ), and is connected to the mixer 50. The first impedance matching circuit 32 is connected between the mixer 50 and the main power source 31, and prevents the AC power supplied from the main power source 31 from being reversed at the mixer 50.

The bias power supply 40 comprises a bias power source 41, and a second impedance matching circuit 42. The bias power source 41 supplies alternating current (AC) power having a predetermined angular frequency ( $\omega_2$ ) and a predetermined amplitude ( $E_2$ ), and is connected to the mixer 50. Here, the lower the frequency is, the heavier a particle reacts the frequency. Therefore, the angular frequency ( $\omega_2$ ) of the bias power source 41 causing an ion to collide with the reaction panel is preferably lower than the angular frequency ( $\omega_1$ ) of the main power source 31.

The second impedance matching circuit 42 is connected between the mixer 50 and the bias power source 41, and prevents the AC power supplied from the bias power source 41 from being reversed at the mixer 50.

The mixer 50 receives the AC powers from the main

power source 31 of the main power supply 30 and the bias power source 41 of the bias power supply 40, respectively, and outputs a predetermined mixed AC power to the lower electrode 12. The mixer 50 is provided to prevent the main power source 31 and the bias power source 41 from being directly connected to the lower electrode 12 to supply mutually AC power to both sources. Herein, the mixer 50 mixes the respective AC powers from the main power source 31 and the bias power source 41 by an operation such as addition. In this embodiment, the addition is used for mixing the AC power, but it should be appreciated that other operation is applicable.

A voltage ( $V_o$ ) outputted from the mixer 50 to the lower electrode 12 is as follows.

<Equation 1>

$$V_o = E_1 \cos(\omega_1 t) + E_2 \cos(\omega_2 t)$$

In the case where the angular frequency ( $\omega_1$ ) of the main power source 31 is much larger than the angular frequency ( $\omega_2$ ) of the bias power source 41, <Equation 1> approximates to the following <Equation 2>.

<Equation 2>

$$V_o = E_1 \cos(\omega_1 t) + E_1 + (E_2 - E_1) \cos(\omega_2 t), \text{ where } \omega_1 \gg \omega_2$$

The voltage ( $V_0$ ) applied to the lower electrode 12 includes " $E_1 \cos(\omega_1 t)$ " employed in generating plasma, and " $E_1 + (E_2 - E_1) \cos(\omega_2 t)$ " employed in adjusting etching conditions.

Such voltage for adjusting the etching conditions may be achieved by supplying at least one auxiliary power having a predetermined frequency and a predetermined amplitude, thereby more precisely controlling the etching.

For example, the main power supply 30 supplies a main power having a frequency of 13.56MHz, and separately the bias power supply 40 supplies a bias power having a frequency of several MHz ~ several hundred kHz. Here, the mixer 50 is employed for preventing a reverse current which may be generated when the powers having the different frequencies from each other are coupled, and for supplying the main power and the bias power at the same time.

With this configuration, the dry etching apparatus 1 according to an embodiment of the present invention is operated as follows.

First, the reaction panel to which photosensitive material is applied is put on the center of the receptor 11. Then, the CCP plasma chamber 10 is vacuumized, and a reaction gas is fed into the CCP plasma chamber 10. Then, the reaction gas is changed into the plasma by the main power source 31 and the bias power source 41 of the power

supply 20. Then, the ion is accelerated by the electric field and collides with a thin film of the reaction panel, wherein a part of the thin film to which the photosensitive material is not applied is etched by the ion.

According to an aspect of the invention, the frequency and the amplitude of the bias power can vary to adjust the etching conditions such as an etching rate, an etching profile, a selection ratio, etc., keeping density of the plasma.

As described above, the present invention provides a plasma chamber in which etching conditions such as an etching rate, an etching profile, a selection ratio, etc. are precisely adjusted.

Although a few embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims and their equivalents.